

## Section 5

### Opinion of Probable Cost

Budgetary capital cost estimates for each category item were developed for consideration in the Town of Amherst's capital planning budgets. Budgetary costs include equipment costs, demolition/removal of existing equipment (if applicable), allowances for contractor markup, installation, general conditions, and engineering and contingency costs. An engineering and contingency allowance of 40% was used in the development of the total capital costs. Table 5-1 summarizes the estimated capital costs by specification section. A detailed opinion of project cost is available in Appendix H.

The conceptual level cost estimates are consistent with the American Association of Cost Engineers standard for a Class 4 estimate. Class 4 estimates are typically prepared for conceptual study purposes. The typical accuracy range for a Class 4 estimate varies from -25% on the low side to +40% on the high side, depending on the level of project definition and detail.

**TABLE 5-1**

Opinion of Probable Cost

<b>Div. No.</b>	<b>Description</b>	<b>Total Costs</b>
1	General Requirements	\$191,000
2	Site Work	\$114,450
3	Concrete	\$127,000
6	Wood & Plastics	\$3,200
7	Thermal & Moisture Protection	\$2,800
8	Doors & Windows	\$11,000
9	Finishes	\$151,000
10	Specialties	\$1,000
11	Equipment	\$462,800
13	Special Construction	\$55,900
15	Mechanical	\$238,820
16	Electrical	\$122,200
	Subtotal	\$1,484,170
	Engineering & Contingency - 40%	\$593,700
	<b>Total Estimate</b>	<b>\$2,077,870</b>
	<b>say</b>	<b><u>\$2,100,000</u></b>

Three large improvement items were identified as items that may be performed by the town or under separate budgets, and are listed separately in Tables 5-2 and 5-3. These items are replacement of the generator and MCCs and the sewer extension work. Table 5-4 provides a cost estimate for exterior building repairs that are considered lower priority than items included in Tables 5-1 through 5-3.

**TABLE 5-2**

Generator and MCC Cost Estimates

<b>Item</b>	<b>Estimated Quantity</b>		<b>Material/Installed Cost (\$/Unit)</b>	<b>Estimated Cost</b>
General Conditions (15%)				\$24,270
Diesel Generator	1	EA	\$54,000	\$54,000
Fuel Tank	1	EA	\$25,800	\$25,800
Motor Control Center for WTP	1	EA	\$64,000	\$64,000
Motor Control Center for Raw Water PS	1	EA	\$18,000	\$18,000
Subtotal				<b>\$186,070</b>
Engineering & Contingency - 40%				\$74,428
<b>Total Estimate</b>				<b>\$260,498</b>
<i>say</i>				<b>\$261,000</b>

**TABLE 5-3**

Sewer Extension Work

<b>ITEM</b>	<b>ESTIMATED QUANTITY</b>		<b>MATERIAL/INSTALLED COST (\$/UNIT)</b>	<b>ESTIMATED COST</b>
General Conditions (15%)				\$160,200
Sewer Manholes	12	LS	\$4,000	\$48,000
PVC Pipe	5,100	LF	\$200	\$1,020,000
Subtotal				<b>\$1,228,200</b>
Engineering & Contingency - 40%				\$491,280
<b>Total Estimate</b>				<b>\$1,719,480</b>
<i>say</i>				<b>\$1,720,000</b>

TABLE 5-4

## Exterior Building Work

ITEM	ESTIMATED QUANTITY		MATERIAL/INSTALLED COST (\$/UNIT)	ESTIMATED COST
General Conditions (15%)				\$74,865
Remove and dispose of wall panels and insulation	7,200	SF	\$5	\$36,000
Remove and dispose of roof panels and insulation	6,600	SF	\$7	\$46,200
Structural Repairs	1	LS	\$5,000	\$5,000
Metal Studs at 16" O.C. <sup>1</sup>	7,200	SF	\$7	\$50,400
Exterior Grade Plywood <sup>1</sup>	7,200	SF	\$3	\$18,000
Wood 2x10 Wood Blocking Along Girts <sup>1</sup>	1,200	LF	\$6	\$6,600
Fiber Cement Board Siding <sup>1</sup>	7,200	SF	\$15	\$108,000
Single Door & Hardware	3	EA	\$3,000	\$9,000
Double Door & Hardware	2	EA	\$4,000	\$8,000
Overhead door	1	EA	\$5,000	\$5,000
Sliding Windows	3	EA	\$2,000	\$6,000
Install New Metal Panel Insulation System	7,200	SF	\$12	\$86,400
Install New Roof Panels and Insulation	6,600	SF	\$10	\$66,000
Remove and Replace Supplemental Man Door Framing	5	EA	\$5,000	\$25,000
Remove, Store, and Reinstall Existing Overhead Rolling Door	1	EA	\$2,500	\$2,500
Remove and Replace Existing Overhead Door Framing	1	EA	\$3,000	\$3,000
Remove and Replace Supplemental Louver & Window Framing	9	EA	\$2,000	\$18,000
Subtotal				<b>\$573,965</b>
Engineering & Contingency - 40%				\$229,586
<b>Total Estimate</b>				<b>\$803,551</b>
<i>say</i>				<b>\$804,000</b>

## Notes

1. Subtract approximately \$100,000 from final cost if metal panels are desired.

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**APPENDIX A**  
**HISTORICAL TECHNICAL MEMORANDUMS**

## Memorandum

**To:** Robert Pariseau  
Jeff Osborne

**From:** John McClellan  
Omer Dumais

**Date:** April 30, 2004

**Re:** Centennial Water Treatment Plant Options – Phase I Conceptual Evaluation

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The purpose of this technical memorandum is to provide an evaluation of options for upgrading the treatment process at the Centennial Water Treatment Plant.

### Background

The Centennial Water Treatment Plant, located in Pelham, was completed in 1981, and treats water from Hill and Hawley Reservoirs. The primary process equipment consists of three package filtration units manufactured by Roberts Filter Group. Each unit consists of two flocculation basins, a sedimentation basin with inclined tube settlers, and a dual media anthracite over silica sand filter, installed within a 46 ft. long by 10 ft. wide steel tank, with the treatment unit processes separated by bulkheads. The nominal capacity of each unit is 350 gpm, translating to a plant capacity of 1.0 mgd with two units operating and a redundant standby unit. The treatment process also includes equipment for feeding coagulant chemicals, and gas-to-solution chlorination and chloramination systems. Polymer is the only coagulant chemical used, at an average dosage of approximately 6.5 mg/L.

Spent backwash water is discharged to a settling lagoon system, consisting of two unlined earthen bermed basins connected in series. Backwash water is discharged to the upstream basin. The upstream basin overflows to the downstream lagoon, and the downstream basin overflows to Harris Brook. The solids are removed from the basins using a loader at intervals of approximately two years.

The capacity of the washwater basins to receive residual solids is limited, thus limiting the amount of coagulant that can be utilized in the treatment process.

Currently, the turbidity removal performance of the plant begins to deteriorate at flow rates of more than about 200 gpm per unit (400 gpm for 2 units on-line, 600 gpm for all 3 units on-line). The plant typically experiences episodes of high color raw water during the summer. The organics removal effectiveness during these episodes has been relatively poor, resulting in high trihalomethane (THM) and haloacetic acid (HAA) monitoring results in the distribution system.

The issues discussed above limit the amount of water that can be produced at the Centennial WTP. At this time the Town wishes to evaluate options for upgrades to the plant that would allow operating the plant at full design capacity while maintaining high water quality.

## Objectives

The Town has the following objectives relative to the proposed upgrades at the Centennial WTP:

- Improve the plant's turbidity removal performance, particularly at high production rates
- Improve color removal
- Reduce disinfection byproduct (DBP) formation, particularly in the summer season

## Coagulants

Following is a general discussion of coagulants that pertains to several of the process upgrade alternatives considered. Commonly used metal salt coagulants include aluminum sulfate (alum), ferric chloride, ferric sulfate, and polyaluminum chloride (PACl) products. Alum was used in the plant during the 1980s. The original alum system was a dry-feed system. Use of alum was discontinued due to several problems, including solids loading on the washwater basins as discussed above. Another problem associated with alum was pH control. The raw water is a low alkalinity water that is subject to fluctuations in pH. The plant was originally equipped with a lime feed system for pH control. The original alum and lime systems required a relatively large amount of maintenance and operator attention and were not effective in maintaining optimal coagulation conditions.

In order for alum to be considered a viable option for the Centennial plant, these problems would need to be addressed. Due to advances in instrumentation and control technology, improved pH control is now possible. Effective pH control could be achieved at relatively modest additional expense, by utilizing the PLC equipment currently being designed, in conjunction with new instrumentation and some additional programming. Also, an alternative pH adjusting chemical such as sodium or potassium hydroxide should be used instead of lime to further improve pH control and reduce operating difficulties associated with lime.

Jar testing of alum, and other metal salt coagulants, in conjunction with polymers, is recommended in order to verify that the treatment objectives can be met, and to determine optimal dosages and pH conditions. Additional improvement in dissolved organic material could be achieved by including a powdered activated carbon (PAC) system in addition to the alum feed system. PAC cannot be utilized without alum (or another metal salt coagulant), because alum is required in order to remove the PAC in the sedimentation process. For purposes of this evaluation, it is assumed that satisfactory removal of dissolved organic material can be achieved with alum or another metal salt coagulant alone, and a PAC system is not included in the cost estimates. It is emphasized that jar testing is required to verify that the treatment objectives can be met.

## Alternatives

Table 1 summarizes the process improvement options considered, expected effectiveness in meeting the treatment objectives, and a cost estimate summary for each alternative. The alternatives are discussed in the following sections. Appendix A contains a listing of assumptions and cost estimate for each alternative. More detailed cost estimates for each of the major process upgrade components are included in Appendix B. Vendor information is included in Appendix C.

# Centennial WIP Treatment Process Upgrade Alternatives Summary

Alternative/Description	Components	Effectiveness			Estimated Costs - March 2004		
		DBPs	Turbidity	Capital	Annualized Capital	Annual O&M	Total Annualized
1a	Periodic Enhanced Coagulation	Some improvement	Some improvement	197,000	14,000	14,000	28,000
1b	Periodic Enhanced Coagulation/UV	Good	Some improvement	648,000	48,000	21,000	69,000
2a	Enhanced coagulation	Good	Good	880,000	64,000	139,000	203,000
2b	Enhanced coagulation/UV	Superior	Good	1,310,000	97,000	148,000	245,000
3a	Contactclarifier	Good	Good	1,440,000	106,000	139,000	245,000
3b	Contactclarifier/UV	Superior	Good	1,890,000	139,000	145,000	284,000
4a	Membrane	Good	Superior	2,370,000	175,000	122,000	297,000
4b	Membrane/UV	Superior	Superior	2,820,000	208,000	158,000	366,000
5a	MIEx Alone	Good	No improvement	1,600,000	118,000	104,000	222,000
5b	MIEx/Membrane	Superior	Superior	3,930,000	289,000	89,000	378,000

### **Alternative 1a: Periodic Enhanced Coagulation**

Under this alternative, the objective is to improve the plant performance with respect to removing dissolved organic DBP precursor material and turbidity during periods when these constituents are at high levels, while continuing the existing treatment practices during the rest of the year. The concept for this alternative is to utilize alum (or another metal salt coagulant such as ferric chloride or PACl) in addition to polymer during periods of high raw water color and/or turbidity. The current coagulation practice would be followed during other periods. The enhanced coagulation would provide more effective removal of dissolved organic DBP precursor material, reducing distribution system DBP levels during periods when they are typically high (i.e., late summer). It is assumed that alum coagulation would be practiced two months per year for purposes of this evaluation.

The capital improvements associated with this alternative include the following:

- Coagulant feed system, including bulk storage tank, transfer pump, day tanks, secondary containment, and appurtenances
- pH control system, including instrumentation, PLC equipment, and upgrades to the existing caustic feed system
- Repair of the existing tube settlers
- Evaluation of the existing filter media and replacement if appropriate

The solids loading on the washwater basins due to the assumed two-month enhanced coagulation period would be increased by roughly 50%, depending on the coagulant and dosage. The additional solids loading would require more frequent solids removal from the washwater basins.

### **Alternative 1b: Periodic Enhanced Coagulation with UV disinfection system**

This Alternative is identical to Alternative 1a, except that a UV disinfection system is included. The UV disinfection system would be utilized for primary disinfection. The current practice is to utilize free chlorine for primary disinfection. Ammonia is added after the free chlorine contact chamber, to form chloramine. A chloramine residual is maintained in the distribution system. Free chlorine is more reactive than chloramine, and typically causes substantially more DBP formation. Thus reducing the free chlorine dosage or contact time would reduce DBP formation.

Utilizing a UV system to provide primary disinfection would allow reduction of the free chlorine primary disinfection dosage, or possibly utilization of chloramine in lieu of free chlorine for primary disinfection. Chlorine or chloramine primary disinfection would still be necessary in conjunction with UV primary disinfection, because UV is not effective at virus inactivation, however it is noted that virus inactivation requires substantially less disinfectant compared to *Giardia lamblia* inactivation. *Giardia lamblia* inactivation controls dosage and contact time for chlorine or chloramine disinfection.

It is assumed that the current practice of providing a chloramine residual in the distribution system would be continued. Reduction of free chlorine contact is expected to lower DBP formation, with the benefit more or less proportional to the extent to which the dosage can be



reduced. Another benefit of UV disinfection systems is that they are effective in inactivating some chlorine resistant microorganisms, including *Cryptosporidium*.

#### **Alternative 2a: Enhanced Coagulation**

Alternative 2a, Enhanced coagulation, is similar to Alternative 1a, except that continuous alum (or another metal salt coagulant) use is proposed. A combination of alum and polymer could be utilized. Due to the increased residuals production associated with alum use, this alternative would require the installation of a sewer connection from the plant to the Amherst town line, a distance of approximately one mile. This alternative would include an alum feed system and appurtenances, pH control system including instrumentation, PLC based controls, and upgrades to the sodium hydroxide feed system. See the discussion of these items under Alternative 1a above.

#### **Alternative 2b: Enhanced Coagulation with UV disinfection system**

This alternative is the same as Alternative 2a, except that a UV disinfection system is included. The UV system would allow reduction in free chlorine contact, providing an additional reduction in DBP formation in the distribution system, and would provide superior inactivation of some chlorine-resistant microorganisms such as *Cryptosporidium*. See the discussion under Alternative 1b above.

#### **Alternative 3a: Contaclarifier**

This alternative involves installing Roberts "Contaclarifier" upflow clarifier units in the sedimentation basins of each of the existing Roberts units. The contaclarifier units would take the place of the existing flocculation and sedimentation processes. The existing filters would remain in service, with filter media replacement if deemed necessary.

In order to meet the color removal and DBP reduction objectives, enhanced coagulation will likely be required with this option. Therefore a pH control system, alum feed system, and sewer connection are included with this option. Jar testing of coagulants is recommended, and a combination of polymer and alum (or other metal salt coagulant) could be utilized. See the discussion of coagulants under Item 1a.

The primary benefit of this alternative over Alternatives 1 or 2 is improved efficiency and ease of operation of the Contaclarifier versus the mechanical flocculators and tube settlers. Particulate removal through the Contaclarifier should be superior resulting in a reduced particulate loading onto the filter media. The newer treatment process is expected to better perform under variations in water quality, be more tolerant of hydraulic variations and be somewhat less burdensome to operate and maintain.

#### **Alternative 3b: Contaclarifier with UV disinfection system**

This alternative is the same as Alternative 3a, except that a UV disinfection system is included. See the discussion of UV disinfection under Alternative 1b above.

#### **Alternative 4a - Membrane filtration**

This alternative includes a membrane ultrafiltration process. In addition, an alum feed system, upgraded pH control system, and a sewer connection are included. Under this alternative, Zenon ZeeWeed 1000 series ultrafiltration membrane systems would be retrofitted in two of the existing Roberts units, in place of the existing filters. The existing rapid mix, flocculation,

and sedimentation systems would be rehabilitated as necessary, and retained in the two units receiving the Zenon systems. The third train could be utilized to treat the waste stream from the membrane filters, or could be taken off line and reserved for future expansion if desired.

The ultrafiltration membrane system will provide superior removal of suspended solids, protozoa, bacteria and viruses, but will not remove dissolved constituents such as color or dissolved organic DBP precursor materials without the use of coagulant chemicals. In order to remove dissolved constituents, an enhanced coagulation/sedimentation process is required prior to the membrane filtration. This system will consist of the existing rapid mix, flocculation, and settling basins, with a new alum feed system, and an upgraded caustic feed system for pH control.

There are two reasons for using alum as a primary coagulant instead of continuing the existing polymer coagulation practice: first, use of polymer is not recommended in conjunction with the membrane system, and second, because it is likely that more effective removal of dissolved organic material can be achieved with alum compared to the current practice of using polymer only. A jar testing program would be required in order to determine the optimal dosage and pH conditions for removing dissolved organic materials and turbidity. It would also be possible to use ferric chloride or polyaluminum chloride (PACl) in lieu of alum, and it may be desirable to jar test these coagulants as well.

Use of alum, ferric chloride, or PACl would result in a substantial increase in the amount of residuals produced at the plant. The existing basins would not be able to accommodate the increase, therefore a sewer connection is included in this alternative.

#### **Alternative 4b – Membrane filtration/UV disinfection system**

This alternative is the same as Alternative 4a, except that a UV disinfection system is included. The UV system would allow reduction in free chlorine contact, providing an additional reduction in DBP formation in the distribution system, and would provide superior inactivation of some chlorine-resistant microorganisms such as *Cryptosporidium*. See the discussion under Alternative 1b above.

#### **Alternative 5a – MiEx System**

The MiEx process is designed to remove dissolved organic material, reducing color and DBP formation. The MiEx utilizes a proprietary, magnetic ion-exchange resin to remove dissolved organic matter. Dissolved organic molecules are exchanged for chloride ions on the surface of the resin beads. The magnetic component allows rapid floc formation and settling of very small resin beads. The small resin beads provide a large surface area per unit volume, resulting in rapid ion exchange kinetics.

The MiEx process does not remove suspended solids, and is typically utilized as a pre-treatment process, installed upstream from a conventional treatment process. Placement before the conventional process is expected to result in reduced coagulant chemical costs and reduced residuals production. The major components in a MiEx process train are a mixing/contact tank, settling tank, fresh resin tank, and resin regeneration tank. Resin is added in the mixing/contact tank, and settled out and recycled in the settling tank. The configuration proposed for the Centennial plant would involve a 1 mgd capacity MiEx system. The MiEx system would be housed in a new pre-engineered metal building installed to the north end of the existing building. The MiEx process continuously consumes salt for resin regeneration,

and produces a concentrated brine waste stream. The amount of salt required and waste brine generated varies on a case-by case basis. Based on average water production and case studies provided by the vendor, salt consumption would be in the range of 500 to 2,000 lb/day, and 300 to 1,000 gal/day of waste brine would be generated.

Under Alternative 5a, the MiEx system would be utilized as a pre-treatment step, with the existing process remaining in place after rehabilitation. The current coagulation practice would be continued, therefore the existing washwater basins would remain in service, and a new waste brine storage tank would be provided, avoiding the need for a sewer connection. Pumping of the brine storage tank and disposal of the brine would be required on a regular basis. We have not identified or evaluated potential sources of disposal for the brine waste but note that options are likely to be limited and the cost may be high.

#### **Alternative 5b – MiEx/Membrane System**

This alternative incorporates the MiEx system described above, with an ultrafiltration system as described in Alternative 4a. This alternative also includes a sewer connection, alum feed system, and pH control system. The sewer connection is included in order to handle the waste brine and wastewater generated by the membrane process, and also to allow enhanced coagulation. The alum coagulation is typically used in conjunction with the MiEx pretreatment, and the combination of these processes would likely provide superior DBP precursor removal. This alternative is based on the assumption that the waste brine could be received at the wastewater treatment plant. This assumptions needs to be verified after bench scale testing of the MiEx process, when a more accurate estimate of the salt consumption can be made.

#### **Recommended Action Items**

Following is a list of recommended action items:

1. Evaluate the condition of the existing filter media.
2. Perform jar testing with alternative coagulants
3. Determine the specific free chlorine (or chloramine) CT if UV disinfection is added
4. Determine the specific rehabilitation needs of the existing equipment
5. Determine available disposal sites and costs if waste brine is generated (MiEx process)
6. Submit a raw water sample for bench scale testing of the MiEx process. The vendor indicated that they will perform this testing free of charge. We recommend submitting a raw water sample during a period in the summer when color is high.

## Memorandum

**To:** Bob Pariseau, Jeff Osborne  
**From:** John McClellan  
**Date:** April 28, 2005  
**Re:** Comments regarding full scale test of PACl coagulant at Centennial WTP

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Coagulant jar testing was performed by Northeast Watertech Services on August 9, 2004. The objective of the jar testing was to evaluate high-basicity polyaluminum chloride (PACl) coagulant with respect to organics and turbidity removal. Increasing the dosage of Nalco polymer, and using polymer in conjunction with PACl, were also evaluated.

The jar testing indicated that PACl coagulant can provide a significant improvement with respect to organics (as indicated by UV absorbance) and turbidity removal compared to the current coagulation practice. The specific chemical tested was PCH 180 by Holland Chemical. The optimal dosage for both UV absorbance and turbidity removal as demonstrated by the jar test was 54 mg/L of PACl chemical, or 3 mg/L as aluminum. The jar testing demonstrated that PACl is effective without pre-coagulation pH adjustment.

The primary disadvantage of PACl (or other metal salt coagulants) compared to the current coagulation practice is residuals production. Use of PACl at the optimal dosage is expected to approximately double the amount of residuals produced per unit volume of water treated.

Full scale testing of the Holland PCH 180 coagulant is planned for the summer of 2005. Objectives of the full-scale test program include:

- Full-scale verification of the effectiveness of the high-basicity PACl coagulant with respect to turbidity and organics removal
- Full-scale verification that PACl can be used effectively without pre-coagulation pH control
- Evaluation of the settling characteristics of the PACl floc and the effect on filter performance
- Evaluation of the amount of residuals production and the residuals characteristics

We recommend conducting an initial round of testing and data gathering using the current coagulation practice in order to establish baseline conditions, followed by a second round using PACl coagulant. As indicated in your March 10, 2005 email, the intent is to use 2 existing day tanks with a combined capacity of 1,200 gallons for the PACl chemical. This will allow approximately four weeks of operation, which we believe is an appropriate test period.

Initial testing with polymer coagulation should be performed during the two weeks immediately before the PACl test. We assume the initial round will be conducted during the last two weeks of July, and the PACl test will be conducted during the month of August.

The following is a summary of desired information and recommendations for data gathering.

1. Turbidity removal: Collect data from on-line instrumentation, no additional sampling necessary.
2. Organics removal: The following sampling program is recommended:
  - a. Raw, settled, and filtered UV254: 1 each per day
  - b. Raw, settled, and filtered TOC: 1 each per week
  - c. Filtered HAA formation potential and THM formation potential: 1 each per week
3. Filter performance: Collect data from on-line instrumentation, no additional sampling necessary.
4. Sludge production: Determination of sludge production based on sludge accumulation in the clarifiers is proposed:
  - a. Determine amount of water production since previous clarifier blow-down
  - b. Measure height of sludge blanket in clarifier immediately before blow-down
  - c. Collect 2 grab samples of sludge before blow-down – analyze for total solids

We recommend doing this at least three times with polymer coagulant and for all blow-downs during the PACI testing.

The following table provides a summary of the recommended analytical samples and estimated costs.

Recommended Analytical Samples and Costs					
Item	Number of samples		Total number of samples	Unit Price	Total Cost
	Polymer coagulant baseline test	PACI coagulant test			
Total solids	6	24	30	\$ 12	\$ 360
UV 254	42	84	126	-	-
TOC	6	12	18	50	900
THM FP	2	4	6	185	1,110
HAA FP	2	4	6	300	1,800
Total					\$ 4,170

We recommend budgeting \$3,000 for engineering services for data analysis and advice/oversight during the test.

We discussed the proposed PACI test informally with Eva Tor at the DEP. She indicated that no formal application is required in order to perform the test, however she requested a letter describing the proposed test, a report of the results, and a letter requesting approval if a permanent change to PACI is desired.

## Centennial Water Treatment Plant – Coagulant Testing

**To:** File  
**FROM:** Amy Lane, Tighe & Bond  
**DATE:** September 22, 2008

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On September 16, 2008, Jonathan Fitts (Polydyne Inc.), Bob Pariseau (Town of Amherst) and Amy Lane (Tighe & Bond) met at the Centennial Water Treatment Plant to test the Polydyne coagulant against the Nalco coagulant that the Town is currently using.

The objectives of the testing were to compare the proposed coagulant to the coagulant currently used. The parameters considered during evaluation were the water quality and the sludge production. Specifically, the proposed polymer would need to produce higher quality water and less sludge to be successful.

The procedure used is as follows:

1. Mixed polymer solutions (100% concentration) to 2.5% concentration, using 500 mL water and 12.5 mL of solution.
2. Added test doses of Polydyne and Nalco to the jars – dosed at 8 mg/L, 9 mg/L, and 10 mg/L. (Therefore, added 0.32 mL, 0.36 mL, and 0.40 mL per 1,000 mL jar, respectively.)
3. Rapid mix at 120 rpm for 1 minute.
4. Slow mix at 20 rpm for 20 minutes.
5. Settle for 20 minutes.

This procedure approximates the procedure used at the Centennial Water Treatment Facility.

No quantitative analysis was conducted (per Amherst). However, visual observations of the jars were noted. Photos of the jar tests are attached to this memorandum. However, it was apparent that the 8 mg/L and 9 mg/L tests were close to the optimum dosing. The 10 mg/L tests appeared to be an overdose, due to the relatively small amount of color removed from the water.

In the side-to-side comparison between the two chemicals, the Polydyne polymer produced higher levels of sludge/flocculant than the same dosing for the Nalco polymer. Water quality (i.e. clarity) for both chemicals appeared to be equal.

Based on visual observations, the Town of Amherst prefers to continue use of the Nalco product. As stated in the objectives, the sludge production needs to be minimized due to the relatively small drying beds for sludge at the facility.

The Polydyne representative verbally concurred with the statement that Polydyne produced greater amounts of sludge than the Nalco, for the same dosing.



Figure 1 – Polydyne Jars (8 mg/L, 9 mg/L, and 10 mg/L)

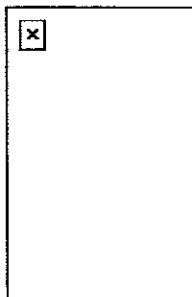


Figure 2 – Polydyne Test at 8 mg/L

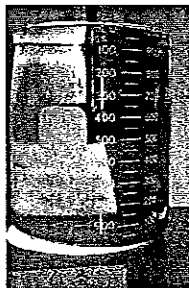


Figure 3 – Polydyne Test at 9 mg/L

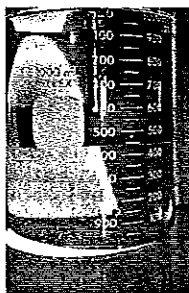


Figure 4 – Polydyne Test at 10 mg/L

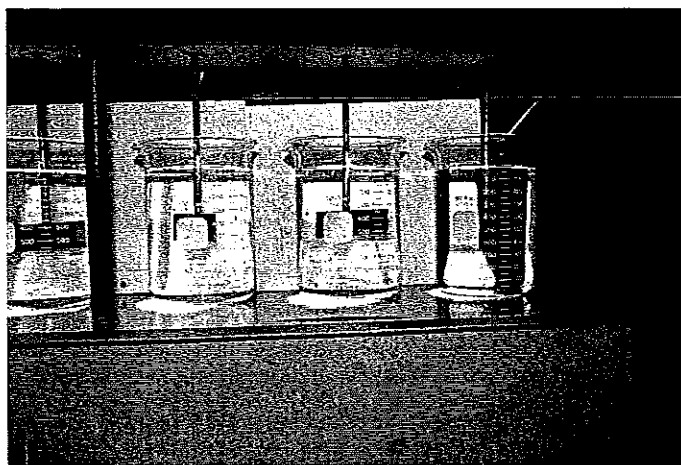


Figure 5 – Nalco Jars (8 mg/L, 9 mg/L, and 10 mg/L)

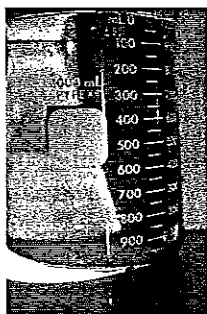


Figure 6 – Nalco Test at 8 mg/L

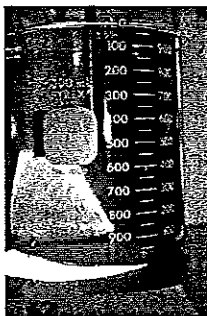


Figure 7 – Nalco Test at 9 mg/L

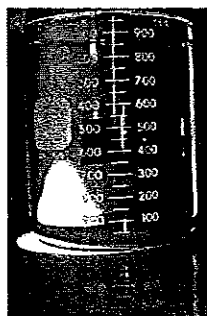


Figure 8 – Nalco Test at 10 mg/L



## **APPENDIX B**

### **ROBERTS UNITS VENDOR INFORMATION**



**Roberts Water Technologies, Inc.** *A Unit of the Roberts Filter Group*

PROVIDING SPECIALIZED PRODUCTS TO THE WATER AND WASTEWATER TREATMENT INDUSTRIES

*Sixth and Columbia Avenue*

*P.O. Box 167*

*Darby, PA 19023*

*[www.robertsfiltergroup.com](http://www.robertsfiltergroup.com)*

*610-583-3131*

*fax 610-583-0117*

July 30, 2010

Tighe & Bond Engineering  
53 Southampton Road  
Westfield, MA 01085

Attention: Ms. Amy Lane

Reference: Town of Amherst, MA  
Reliant Replacement Parts  
Roberts original contract #1986

Subject: Roberts' Budget Proposal BP-AT-10-1180-T revision 1

Dear Ms. Lane:

Roberts Water Technologies, Inc. ("Roberts") is pleased to provide the below proposal for parts for the rehabilitation of the three (3) Roberts FSG Units at the Amherst, MA Water Filtration Plant as follows.

#### **Scope of Work**

##### **Flocculators & Drives**

1. Six (6) Vertical Flocculators each with 1/2 HP variable speed motor and SCR controller (two for each unit). The flocculators have a 304 SS shaft and arms with FRP paddles, and include a bottom bearing support with all 304 SS mounting hardware provided. These are provided for installation by others on the existing supports.

---

*The ROBERTS FILTER GROUP of Companies*

*Roberts Water Technologies • Roberts Environmental • Roberts Services • Roberts Leotech • Roberts Filter International • Roberts of Puerto Rico*

### **Optional Items**

Roberts recommends that the surface wash agitator's be replaced with a Managed Air Scour system. The upgrade from surface wash to air scour has been shown to improve filter run times, reduce backwash water requirements and improve filter effluent water quality.

### **Substitution of ARIES® Managed Air System, Blower and Air Valves for Rotosweeps**

#### **ARIES® Managed Air Scour Units**

1. A total of three (3) ARIES® modules each designed to cover an area of approx. 10'-0" x 10'-0" and support hardware shall be furnished; one (1) for each filter bay. Individual components of the ARIES® modules and diffusers shall be fabricated of Type 304L stainless steel. Support hardware shall be fabricated of Type 304L stainless steel.
2. Drop pipes (3" diameter) shall be furnished for installation by others for connecting the ARIES® modules to the air supply piping. Drop pipes shall be fabricated of Schedule 40, Type 304L stainless steel.
3. In-filter supply piping between the air scour isolation valve and the ARIES drop pipe will be provided. Air supply piping shall be Sch. 40, Type 304SS.
4. Support hardware for air supply piping shall be furnished and installed fabricated of Type 304 stainless steel.

#### **Air Blowers System & Valves**

1. Roberts shall furnish one (1) air blower package, sized for 250 scfm at 160". Air blower motor shall be 15 HP, 1800 RPM, TEFC 230 / 460 V, 3P, 60 Hz. The blower shall include inlet and outlet silencers, inlet filter, PRV, check and manual shut off valve and pressure gauge.
2. Three (3) 3" Dia. Industrial quality wafer butterfly valves with electric open/close actuators (120 VAC) shall be supplied for installation & wiring by others.

### **Budget Pricing:**

#### **Base Scope:**

One Hundred and Twenty Nine Thousand Dollars    \$129,000.00

Individual Break-outs, calculated on estimated percentage of total project costs.

Flocculators:	\$64,500
Tube Settlers:	\$32,250
Media:	\$19,350
Surface Wash:	\$12,900

**Recommended substitution of ARIES®, Supply Piping, Blowers & Air Valves for Rotosweeps**

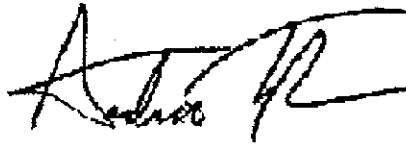
Twenty Seven Thousand Dollars: \$26,700.00

**Items not included:**

Concrete Tank Drawings, Concrete work, backwash pumps, motor starters, catwalk systems (except as noted), face piping or pneumatic piping, chemical bulk storage or transfer equipment or installation labor.

We thank you for the opportunity of submitting our budget proposal to you for your consideration. If you should have any questions please feel free to contact me. Thank you.

Respectfully yours,  
ROBERTS WATER TECHNOLOGIES, INC.



Andrew S. Taylor  
National Sales Manager

AST:gdr

CC: File  
Chuck Rossiter/Bartlett & Brillon LLC

## Christina L. Stauber

---

**From:** Chuck Rossiter [Chuck@BartlettBrillon.com]  
**Sent:** Wednesday, November 10, 2010 8:21 AM  
**To:** Christina L. Stauber  
**Subject:** FW: Roberts Filter revised quote

Christina,  
Please see Andy's comments below.

Best regards,  
Chuck Rossiter  
Sales Engineer  
Bartlett & Brillon LLC  
595 Providence Hwy  
Walpole, MA 02081  
(508) 668-1337 voice  
(508) 850-9599 fax  
(617) 549-4828 cell

-----Original Message-----

From: Taylor, Andrew [mailto:ataylor@robertsfilter.com]  
Sent: Wednesday, November 10, 2010 7:23 AM  
To: chuck@bartlettbrillon.com  
Subject: RE: Roberts Filter revised quote

Chuck-

A second (redundant) blower delivered to Amherst would be around \$11,000.00. I think redundant blowers for air scour systems are a waste of money, but it isn't uncommon to supply two. Call with questions.

Andy

-----Original Message-----

From: chuck@bartlettbrillon.com [mailto:chuck@bartlettbrillon.com]  
Sent: Friday, November 05, 2010 12:16 PM  
To: Taylor, Andrew  
Cc: Mike Brillon; Harlan Bartlett  
Subject: Fw: Roberts Filter revised quote

Sent from my Verizon Wireless BlackBerry

-----Original Message-----

From: "Christina L. Stauber" <CLStauber@tigheBond.com>  
Date: Fri, 5 Nov 2010 10:59:03  
To: 'Chuck@BartlettBrillon.com' <Chuck@BartlettBrillon.com>  
Subject: Roberts Filter revised quote

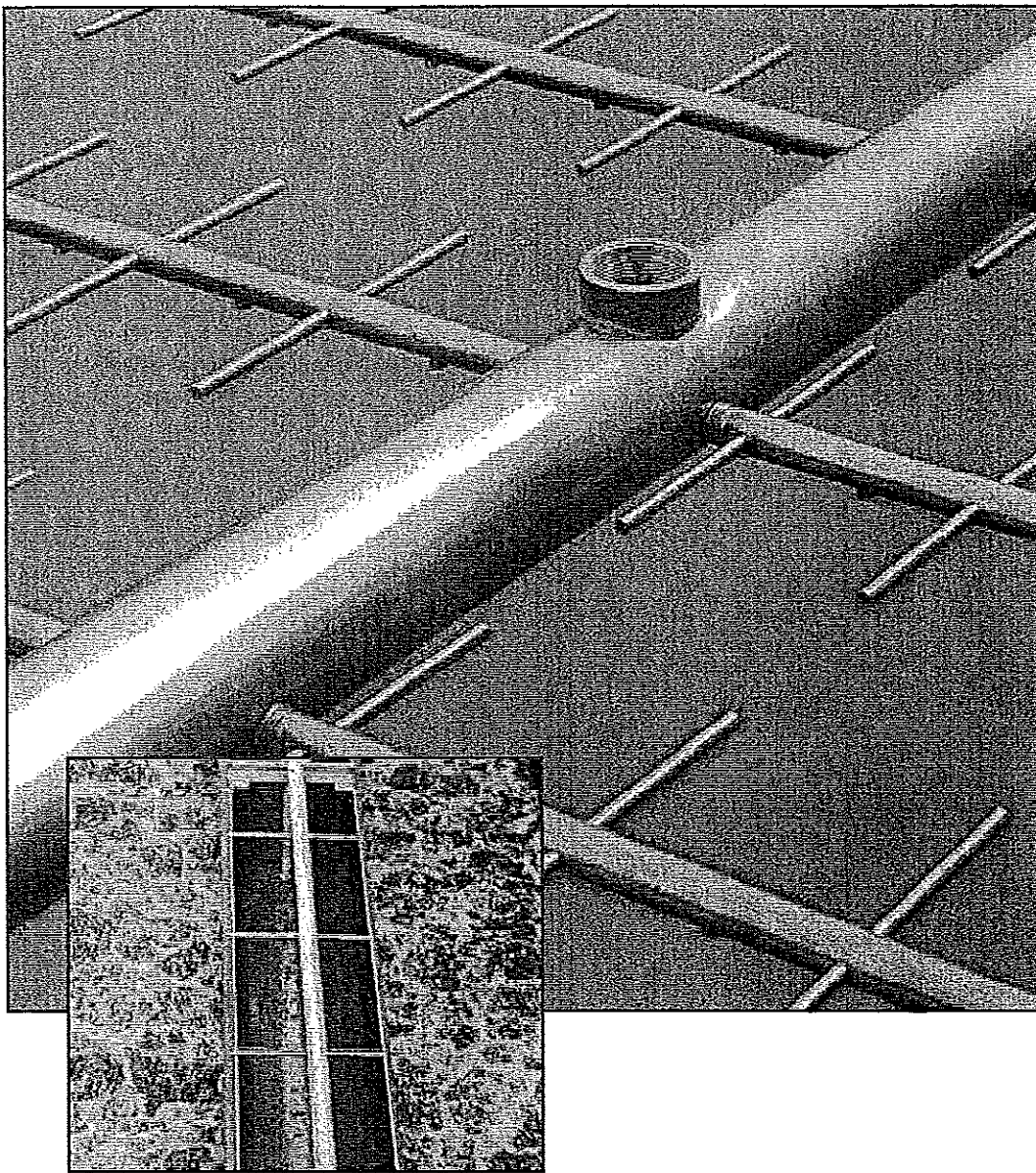
Hi Chuck,

In response to your quote (attached) for the Robert's Filter rehab at Amherst, the Town of Amherst would like a redundant blower provided with the ARIES air scour system. Can you provide me with the added cost required for that?

Thanks,

Christina L. Stauber

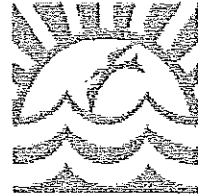
Tighe&Bond  
53 Southampton Road  
Westfield, MA 01085  
(P) 413-572-3295  
(F) 413-562-5317



TECHNOLOGIES



ENVIRONMENTAL



PUERTO RICO



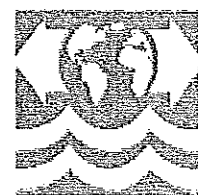
LEOTECH



SERVICES



INTERNATIONAL



# ARIES®

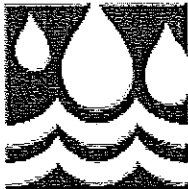
## Managed Air System



**Roberts Water Technologies, Inc.®**  
*A Unit of the Roberts Filter Group*

Main Office: Sixth and Columbia Ave. • Darby, PA 19023  
 (610) 583-3131 • Fax (610) 583-0117 • [www.robertsfilter.com](http://www.robertsfilter.com)

*Providing Specialized Processes and Systems to the Water and Wastewater Treatment Industries*



## ARIES® MANAGED AIR SYSTEM

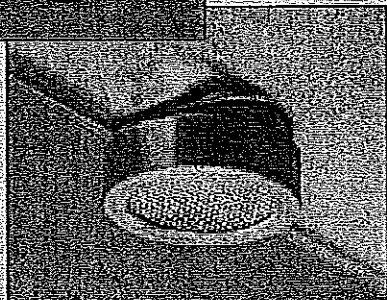
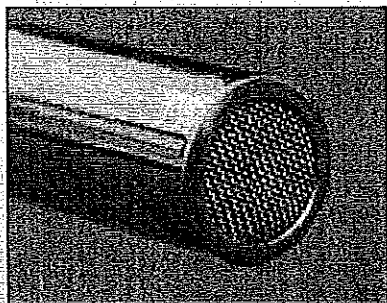
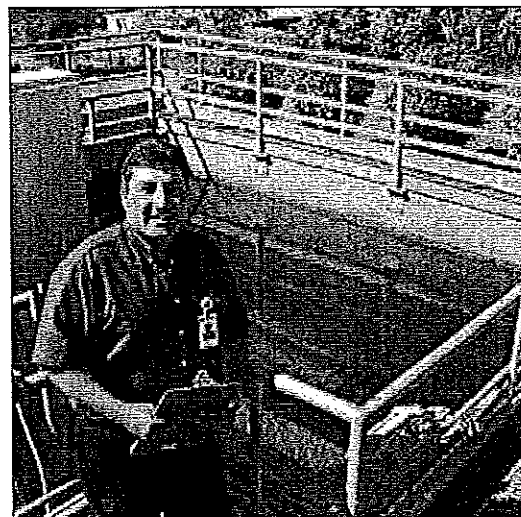
INCREASE EFFICIENCY AND REDUCE COST  
FOR NEW OR EXISTING FILTER SYSTEMS

*Stringent effluent water quality standards require filtration systems to be in top operating condition. The Aries® Managed Air System removes particulate matter more effectively than existing conventional methods.*

### ARIES®

**MAKES YOUR JOB EASIER WHILE IMPROVING EFFLUENT WATER QUALITY**

- Bottom to Top Agitation eliminates mudballs and compaction
- Maximize air scouring efficiency and reduce backwash water consumption up to 70%\*
- Near perfect air flow distribution provides complete cleansing and restoration of filtration media at lower air rates
- Reduced air requirements - 2.5 SCFM/SF
- Longer filter runs increase service capacity
- Better media cleaning and longer media life
- Designed for use with new or existing underdrain system
- Installation and operation with virtually no downtime
- Replaces existing surface wash systems
- Easy installation and removal without removing the media - simply fluidize the filter bed



### ARIES® CONSTRUCTION

*Improvements in Backwash Operation  
and Service Monitoring*

- Type 304 or 316 stainless steel construction for long service life, compatibility in all applications
- Major sub-components factory assembled for maximum reliability
- Lightweight for in-filter assembly and installation
- Air application at the point of use - no dissipation of energy
- Separate air conduit for air distribution eliminating chance of water hammer damage and subfill upset

*\*From actual operating experiences at Morrisville, PA*



# ARIES®

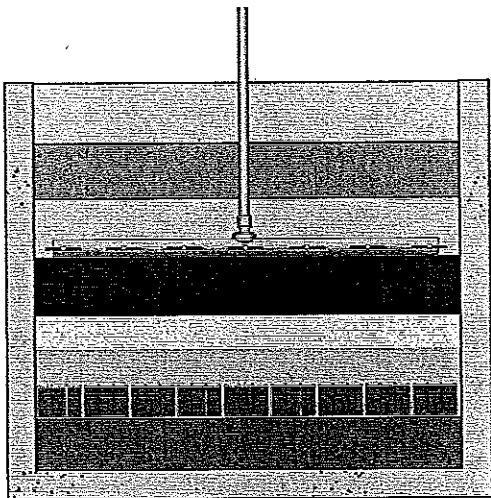
## Evolution of a Proven Design

*Because of the Aries unique modular design, installation can be accomplished **without** underdrain modification or replacement. Each Aries system is completely independent from the filter underdrain system.*

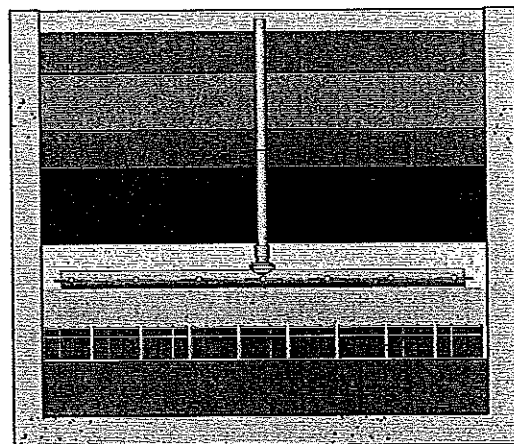
### ARIES®

#### INSTALLATION AND OPERATION WITHOUT UNDERDRAIN MODIFICATION

#### QUICK AND SIMPLE INSTALLATION

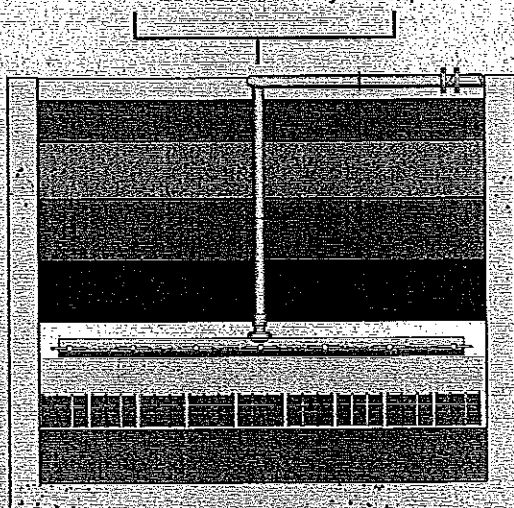


- 1 Assemble the unit on top of the filter bed

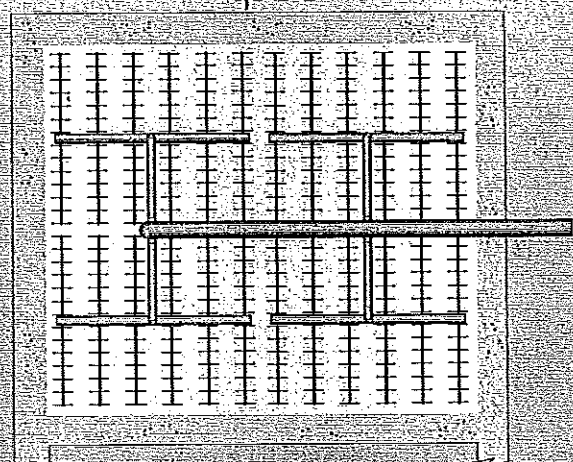


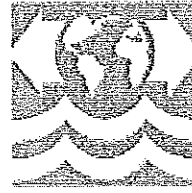
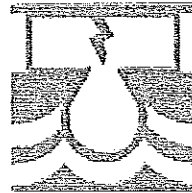
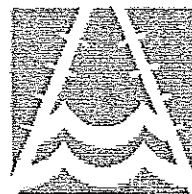
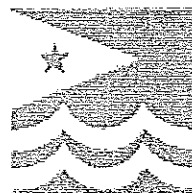
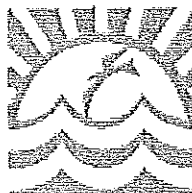
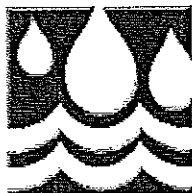
- 2 Fluidize the media, by initiating a back-wash allowing the unit to settle at the gravel/media interface

- 3 Simply complete the air piping installation and the Aries is ready for operation



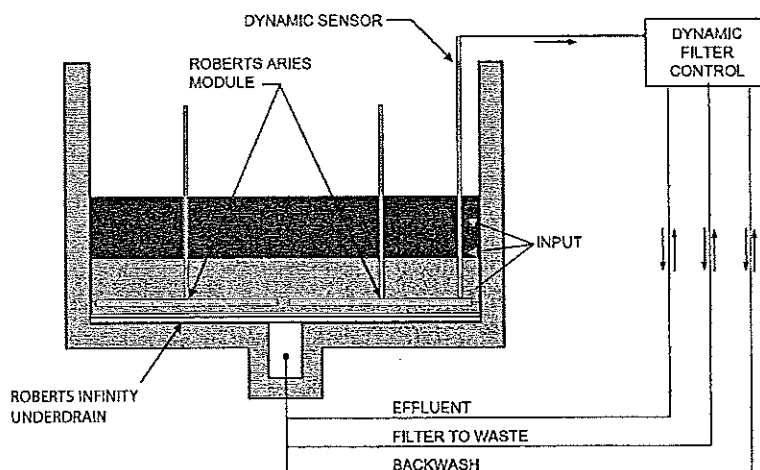
Typical Aries Layout





## 21st Century Filters

### The Best Available Technology for AFM\*



*Take control of your water filtration requirements with our 21st Century options:*

- **INFINITY®** Continuous Lateral Underdrain – minimum depth for maximum filter performance
- **ARIES®** Managed Air System – bottom to top agitation for complete media cleansing
- **DYNAMIC PROBE®** – operational monitoring for service and backwash

*\*For Anticipatory Filter Management information please contact Roberts Water Technologies, Inc. or our representative in your area.*

*Represented by:*



**Roberts Water Technologies, Inc.®**  
A Unit of the Roberts Filter Group

Main Office: Sixth and Columbia Ave. • Darby, PA 19023  
(610) 583-3131 • Fax (610) 583-0117 • [www.robertsfilter.com](http://www.robertsfilter.com)

U.S. Patents Nos. 5,534,202; 5,673,481

Other Foreign Patents Pending

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A Unit of the Roberts Filter Group

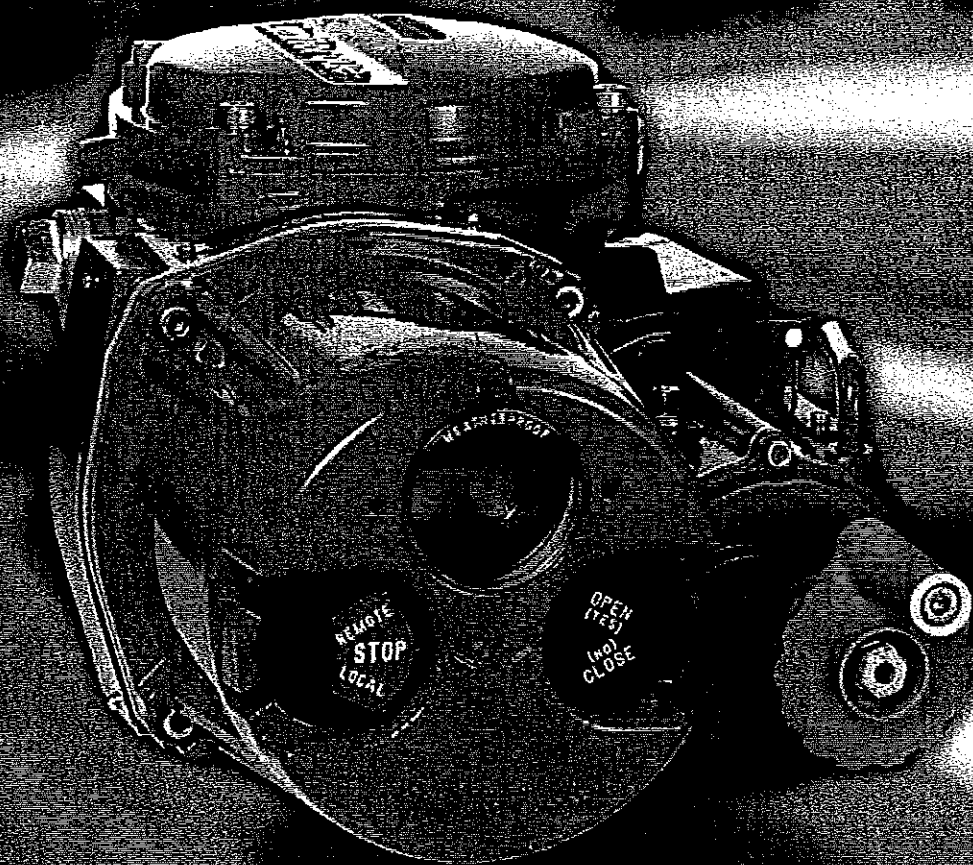
Printed in USA

**APPENDIX C**  
**VALVE PRODUCT INFORMATION**

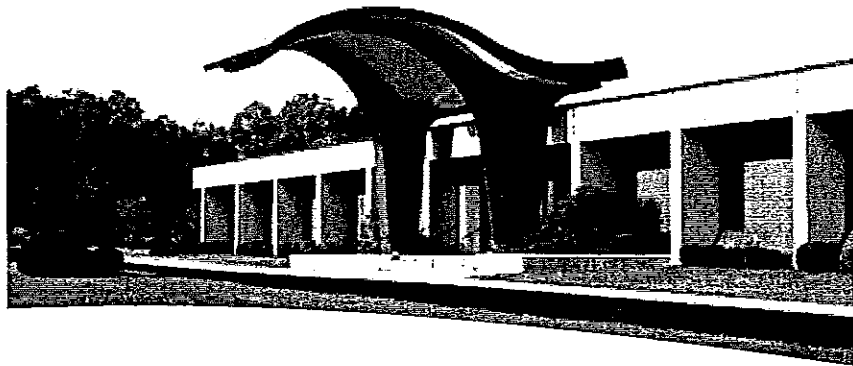
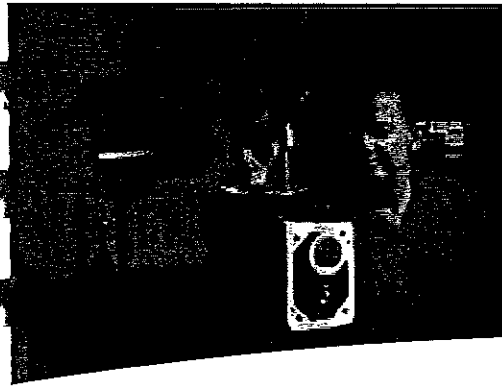


## *Limitorque QX*

The Next Generation in Smart Quarter-turn Actuation



*Experience In Motion*



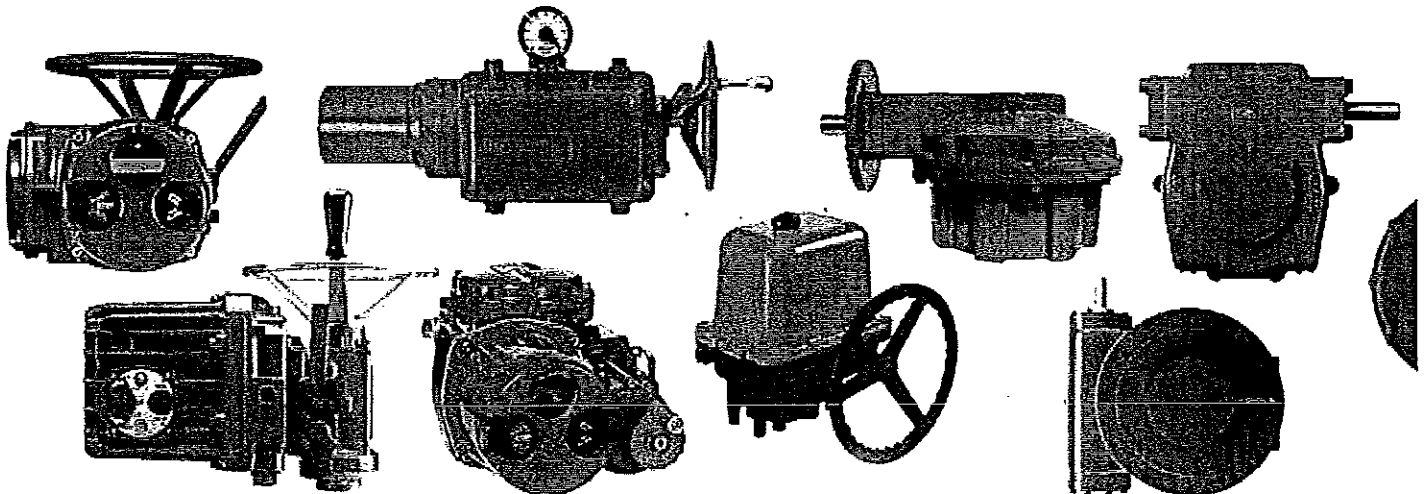
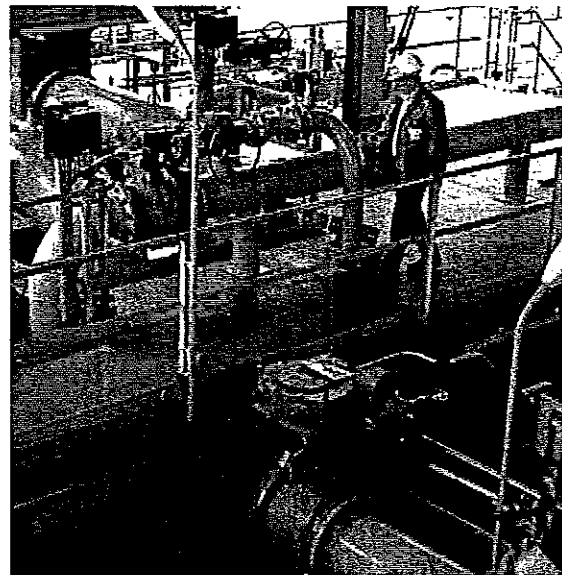
## ***Flowserve Limitorque Actuation Systems***

Limitorque is an operating unit of Flowserve, a \$4 billion-plus/year company strongly focused on automation and support of the valve industry. Flowserve is the world's premier provider of flow management services.

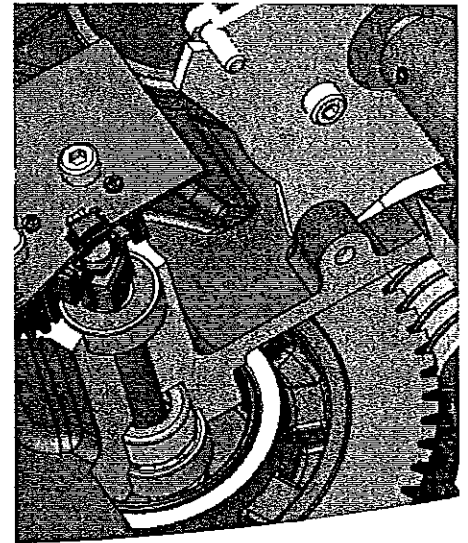
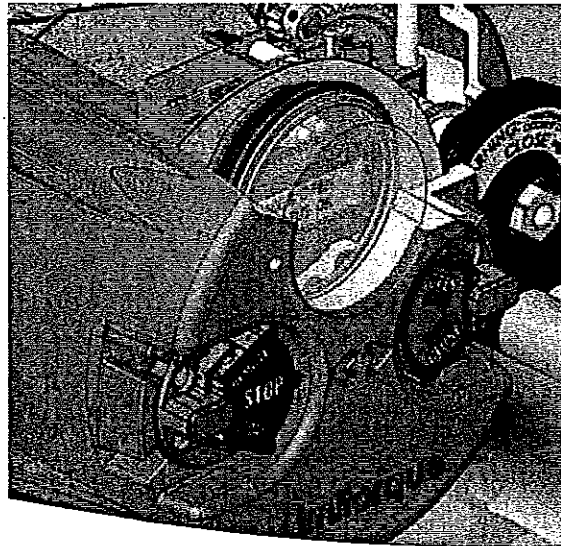
Limitorque has evolved over 80 years since its strategic introduction of a "torque-limiting" design that changed an industry. Flowserve Limitorque offers solutions and automation choices for customers that provide:

- Cost savings from field devices such as electric valve actuators
- Greater operating efficiencies from control-room performance sequencing, interlocking and continuous process optimization
- Competitive advantages derived from increased management visibility of databases and networks

*Limitorque is one of the primary reasons Flowserve is "Experience In Motion."*



*The QX speaks your language, whether it's management, technical, financial, operations or service.*

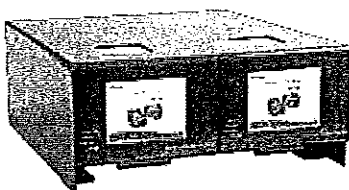
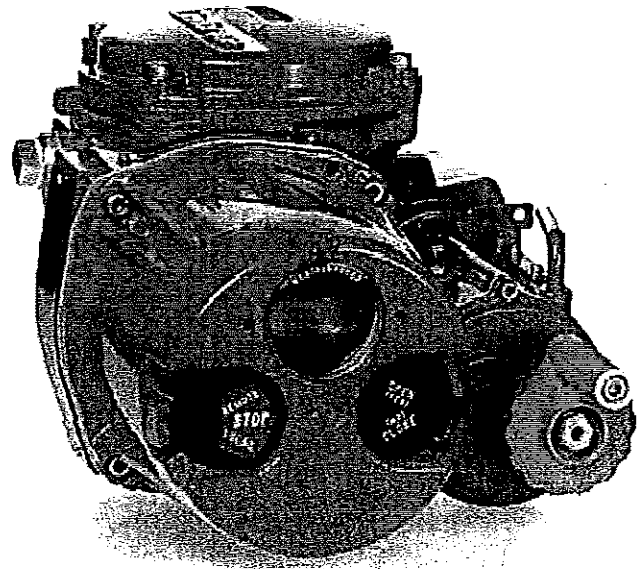


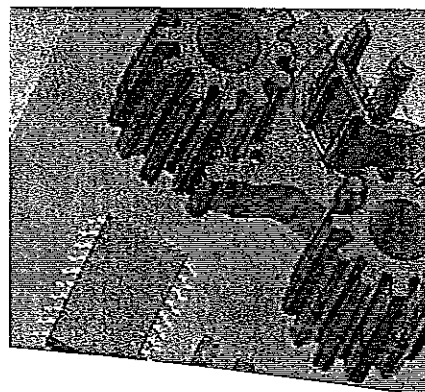
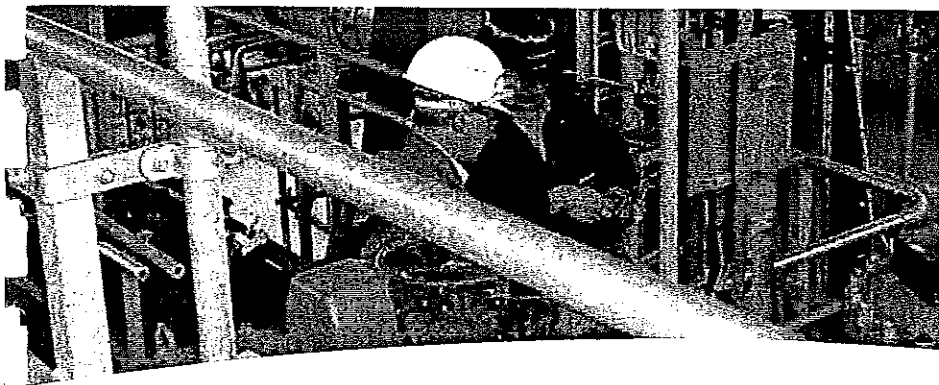
## ***Limitorque QX Smart Valve Actuator***

*The full measure of safety and reliability in the next-generation smart quarter-turn actuator.*

The Flowserve Limitorque QX quarter-turn smart electronic valve actuator continues the legacy of the industry's state-of-the-art, non-intrusive, multi-turn MX actuator by including a patent-pending absolute encoder for tracking position without the use of troublesome batteries. The QX design provides enhanced safety and reduced downtime through improved diagnostics, built-in self-test (BIST) features and LimiGard™ fault protection.

The QX design builds on more than 10 years of experience with proven Limitorque MX technology—the first-generation double-sealed electronic valve actuator from Flowserve designed to provide control, ease of use and accuracy. The QX includes all the user-preferred features of the MX in a quarter-turn smart actuator package. It is the only non-intrusive, double-sealed quarter-turn actuator to display the Limitorque brand.





## ***QX: The Next Generation in Smart Quarter-turn Actuation***

### ***Speed, Precision and Simplicity***

The QX control panel features an improved 32-character LCD screen that provides actuator status and diagnostics in an easy-to-use, easy-to-read, graphical format. The industry's first non-intrusive, quarter-turn multilingual actuator is configurable in English, Spanish, German, French, Italian, Portuguese, Mandarin, Russian, Bahasa Indonesia and Katakana as standard configuration languages. In addition, the LCD can be rotated 180° for better field visibility.

User friendliness, precision, simplicity, and intuitive setup are characteristics expected of a smart actuator. Users and valve OEMs demand quick setup and easy-to-understand dialogue in preferred languages. The ability to either upload new software or download diagnostics is also critical to improving a plant's efficiency. The QX provides customers with the essential tools for rapid installation and root-cause diagnostics.

Precision is expected in a smart actuator. The MX was the first such device developed with a patented absolute encoder that doesn't require troublesome and unpredictable

battery backup. Flowserve Limitorque's innovative absolute encoder technology, developed for the MX, is used in the QX. The QX encoder employs system-on-chip technology using a contactless magnet that excites Hall-effect devices to provide redundant, 12-bit resolution over 360 degrees. This redundancy, part of the BIST (built-in self-test) feature, means the device can continue to function reliably until a number of faults have been accumulated.

When a device is designed for BIST, its methodology is such that much of the test functionality is embedded in the device itself. BIST design enables a critical component's ability to communicate its actual state to a CPU for comparison to the expected state. Any deviation from expected values will be reported to the user, with correlation to the failed component or subsystem.

Simplicity is expected in a smart actuator. In fact, one of the reasons for using an electronic actuator is the simplicity of setup, installation on a valve and acquiring diagnostic information. The QX is the simplest and easiest to use electronic quarter-turn actuator.







### ***Long Life and Protection***

Long life is expected in a smart actuator. There are more than 1,000,000 Limitorque actuators installed around the globe, in every conceivable environment. Many have been functioning for over 50 years. This legendary Limitorque longevity has been carried over into the QX family of smart actuators. The QX has been developed with the ruggedness and dependability users have come to expect from Limitorque actuators for better than 80 years.

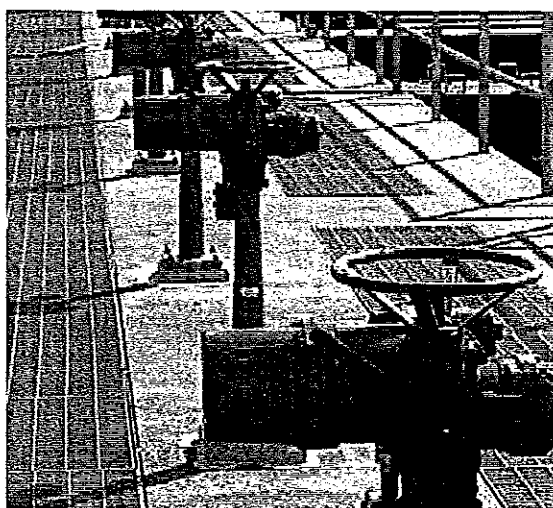
In order to last a long time in severe environments, smart actuators must have unparalleled protection. The QX's IP68 enclosure rating is 20M for 168 hours, regardless of whether the unit is weatherproof or explosion-proof. This is an industry-leading feature. Add other certifications to the list – NEMA 4, 4X, 6 – and the QX is unsurpassed in unit protection.

The QX is double-sealed, which isolates the terminal compartment from the controls environment. Any leakage into the terminal compartment is contained in the compartment.

The QX is powder coated using a polyester resin in Dupont Blue Streak color, not only for aesthetics, but also for protection in severe corrosive environments. The use of powder coating ensures that each QX can withstand saliferous conditions without degradation.

### ***Quality and Certifications***

Flowsolve Limitorque is a global leader in quality manufacturing. All Limitorque plants are certified to ISO 9001 standards, the recognized benchmark for quality all over the world. The same unexcelled use of certified



materials is found in the QX as in Limitorque's naval and nuclear-qualified electric actuators. The MX has used synthetic gear oils especially optimized for use with worm-gear sets since the first unit was shipped in 1997, and the QX is no exception. All lubrication used in the QX is synthetic, capable of temperature extremes from -60°C to +70°C. The MX was the first non-intrusive actuator to use rolled worms and electronic controls, designed and produced using surface-mount technology: the QX uses components manufactured with the same advanced technology. A true globally certified device, the QX meets all pertinent European directives including ATEX, EMC, Machinery and Noise, and displays the CE mark associated with such compliance.



## Anatomy of QX Quarter-turn Actuators

Limiterque QX actuators respond to customer needs with advanced features designed for ease of commissioning and use, as well as time- and money-saving operational benefits. What sets the QX apart is the combination of control and reliability enabled by advanced Limiterque technology, plus superior ergonomics and human interfaces for speed, comfort, and ease of use.

### Brushless DC Motor

Advanced brushless DC motors eliminate sparks, reduce mechanical and electrical noise, and dissipate heat better than brushed motors. Unique to the industry, brushless motors last longer than conventional motors and allow for more accurate positioning while permitting a global range of voltages (single-phase and three-phase AC and DC) to be used without modification.

### Terminal Chamber

Double-sealed design provides a termination chamber that is separate and sealed from the control chamber. Control components are never exposed to the elements during site wiring or because of a faulty cable connection.

### Absolute Encoder

The QX encoder employs system-on-chip technology using a non-contacting magnet to excite Hall effect devices, providing redundant, 12-bit resolution over 360°. This redundancy, part of the BIST feature, means the device can continue to function reliably until a number of faults have been accumulated.

### Worm Gear Set and Motor Gear Attachment

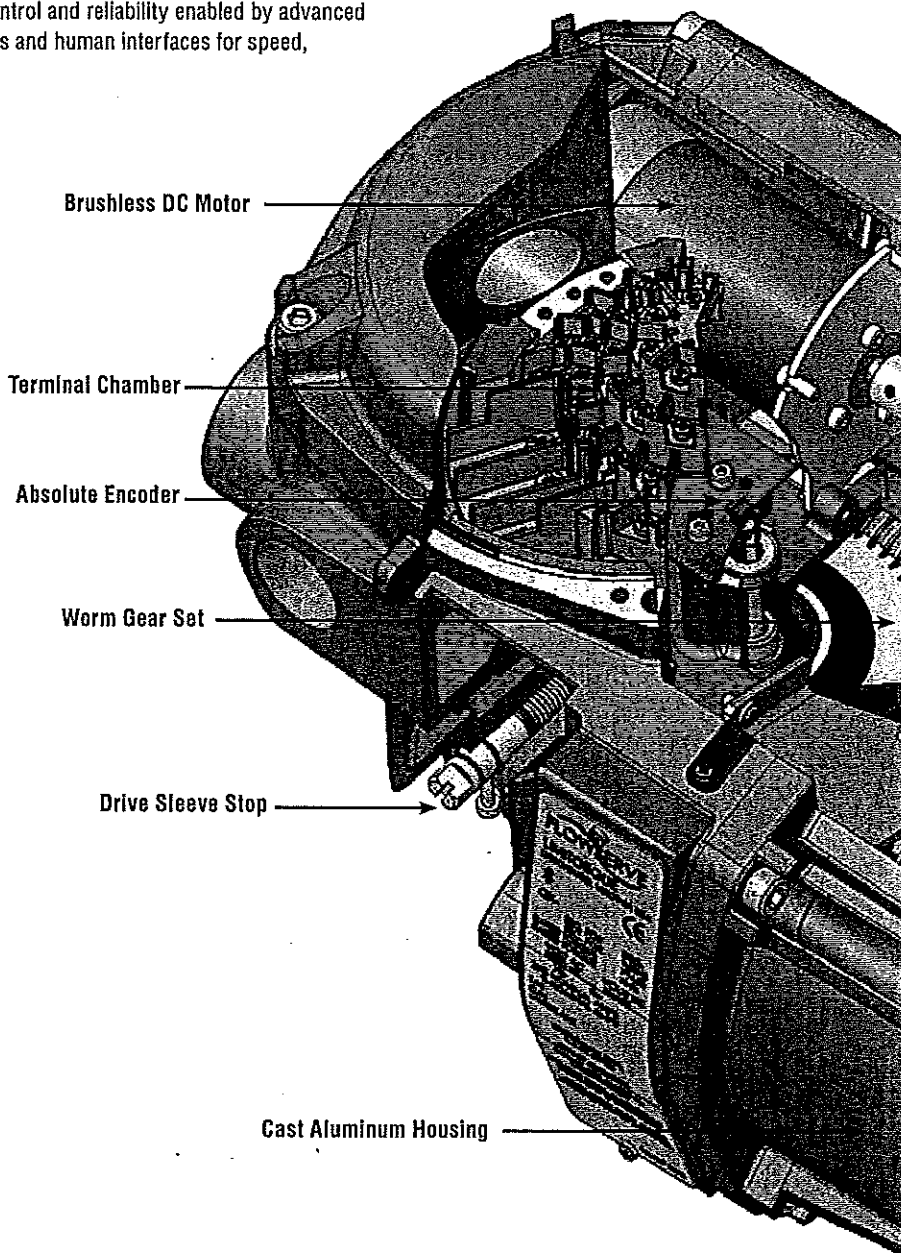
Both the motor gear reducers and worm gear sets are designed with Limiterque performance and longevity in mind. Rolled/ground gears are bearing supported and immersed in an extended life synthetic gear oil specifically designed to improve efficiency and minimize wear.

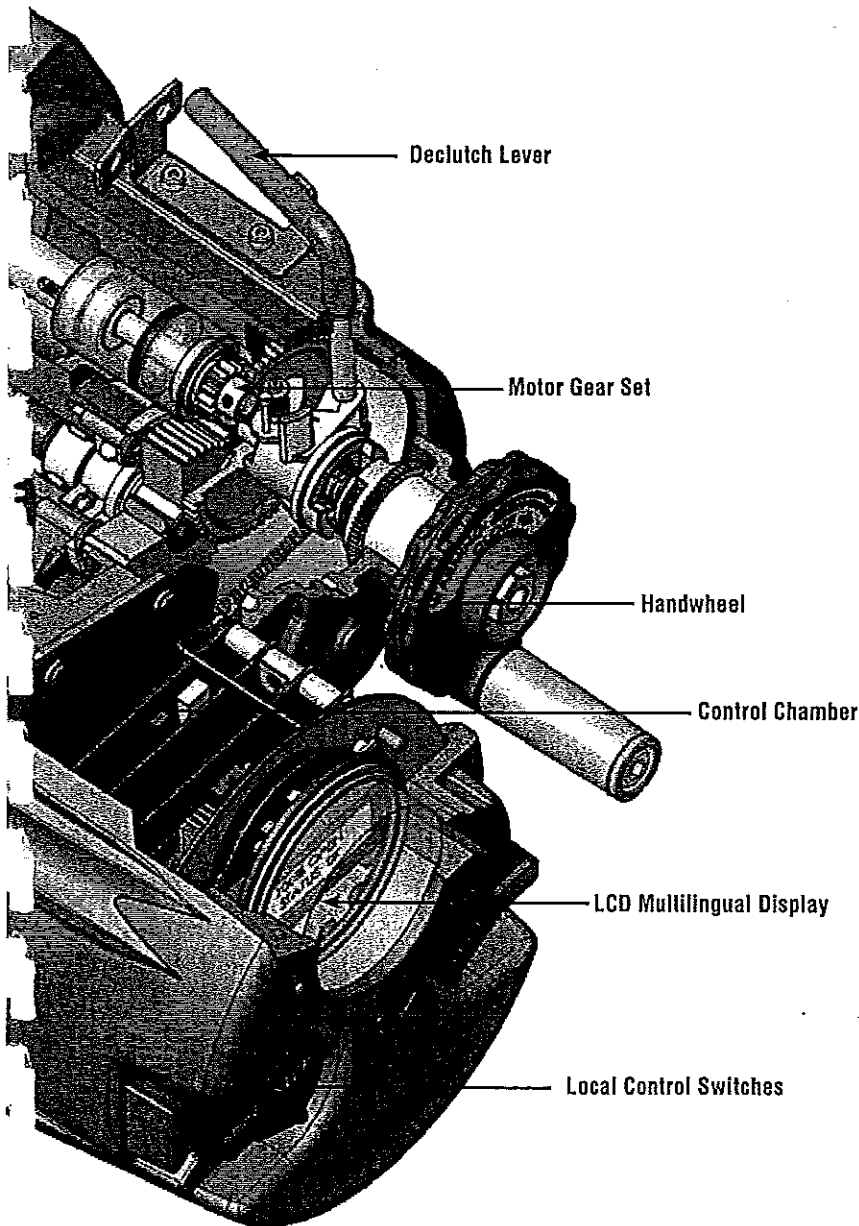
### Drive Sleeve Stop

Drive sleeve stops are supplied for 90° selections and removed for multi-turn applications, up to 20 turns maximum.

### Cast Aluminum Housing

The QX housing material is cast 356-T6 grade aluminum. This alloy was selected due to its superior suitability for corrosion resistance in harsh and eroding environments.





#### **Declutch Lever**

*Declutch lever enables the QX actuator to be placed in manual, handwheel-drive operation. Lever automatically disengages when motor is energized and can be padlocked in the motor position.*

#### **Torque Sensing**

*The QX continues the Flowserve Limitorque commitment to fully electronic smart actuators with advanced torque sensing. This method of torque control uses motor amperage to sense the valve load and has been verified in temperature extremes from -30°C to +70°C.*

#### **Handwheel**

*QX handwheels are manufactured from an engineered resin and are designed to meet most minimum rim pull requirements. Locating the handwheel adjacent to the LCD and controls facilitates local configuration and operation.*

#### **Control Chamber**

*Utilizing the same electronics package as the state-of-the-art MX, the QX has an additional feature - a solid state motor controller. This design permits almost all customer supplied voltages, single or three phase AC or DC, to be connected without modification to the voltage supply.*

#### **LCD Multilingual Display**

*The control panel display delivers instant, up-to-the-minute actuator status and valve position in 10 languages. It also provides simple calibration and diagnostic information, including motor, identification, and hardware data, as well as torque profile and log reports.*

#### **Local Control Switches**

*Local control switches make setup and calibration easy, using "yes" or "no" responses to straightforward questions, plus they provide the ability to open, stop and close the actuator and to select remote or local preferences. These switches are magnetically coupled, solid-state Hall effect devices, which eliminate troublesome and fragile reed switches.*

## Control and Diagnostics

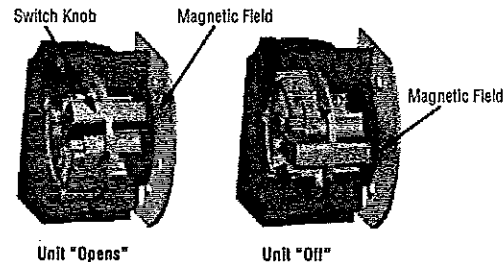
*Control is expected in a smart actuator. The QX simplifies valve automation in three critical methods of control:*

- Calibration/setup
- Normal operation
- Diagnostics and troubleshooting

The MX was the first non-intrusive actuator to equip users with LCD dialogue screens in the language of their choice. The QX has the same language options as the MX and uses a graphical dot matrix display that improves the visibility of the display. The use of this type of LCD permits the support of any language. In fact, in addition to English, Spanish, German, French, Italian and Portuguese, the QX also includes four character-based languages – Mandarin, Russian, Bahasa Indonesia and Katakana – with a capacity for even more.

Simple "Yes" and "No" responses to dialogue questions confirm the setup of the QX via solid-state Hall effect devices in both knobs. No special tools or remote devices are required. And the QX is "fit for service", offering the widest range of configuration menus of any non-intrusive smart actuator.

Diagnostics should be easy to read and decipher. The QX diagnostic enhancements now offer a BIST (built-in self-test). The BIST feature is also designed into a state-

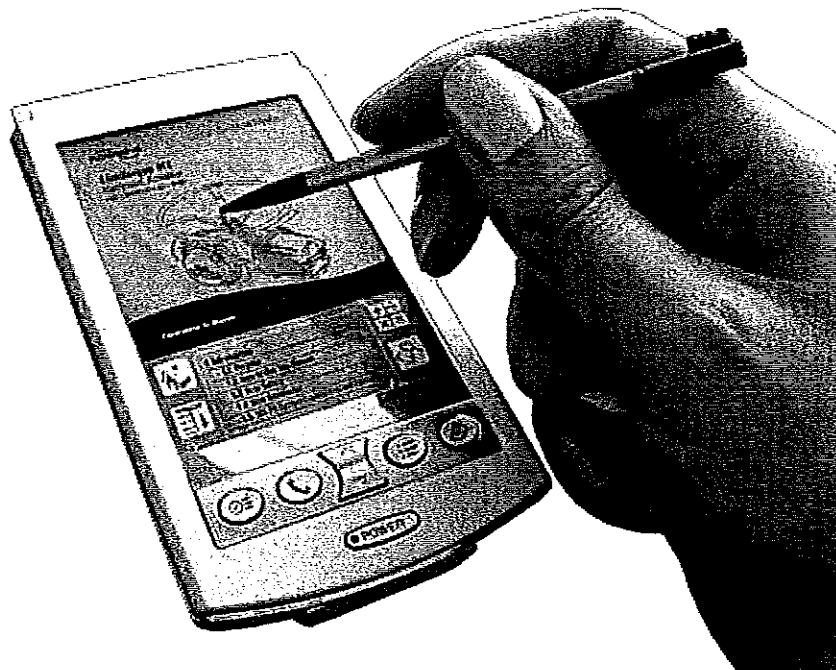


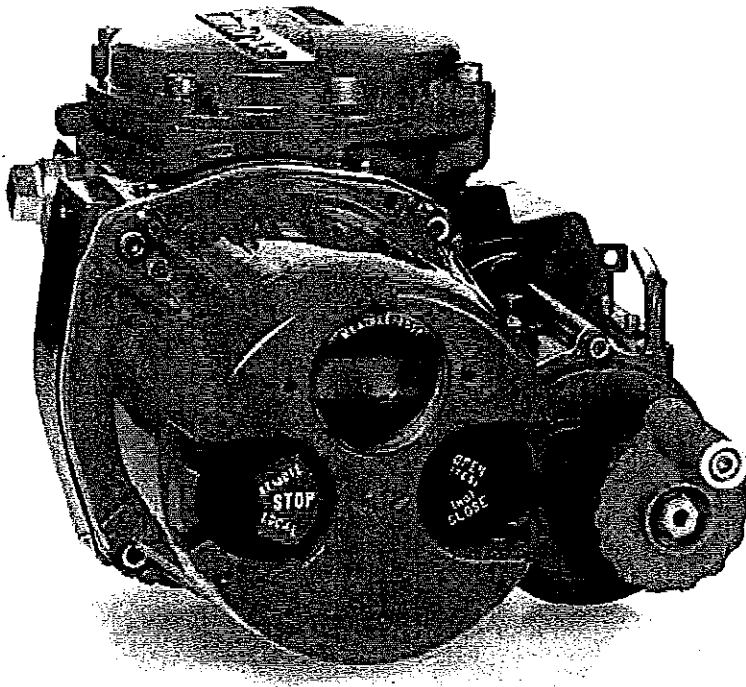
NOTE: Illustration for information only.

Hall effect devices interlocked to prevent operation

of-the-art controls platform that verifies and validates the integrity of its components. The result is a design that aids the user in meeting the SIL (Safety Integrity Level) requirements of IEC 61508. Placing a smart device into any plant system enhances the ability of a given safety system to achieve its preferred SIL rating. Any device that incorporates fully developed BIST features provides assurance to the user that the device has been designed with plant-wide safety and integrity of operation in mind.

The "View Diagnostics" menu selections now include more definitive routines that can isolate troubleshooting to "root cause" error codes. These root-cause codes can be used in conjunction with BIST. A well-designed BIST-based system can do more than just report failures in the electronic subsystems: it can also determine failures or

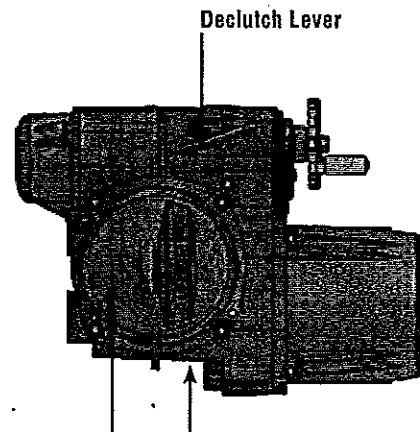




predict future failures in its associated mechanical system. To further enhance QX diagnostics, a new component has been added to the patented Limigard feature – Frequency Domain Analysis.

The Frequency Domain Analysis (FDA) methodology for QX is based upon capturing torque, position or speed values at regular time intervals while the actuator is motoring, and then calculating the resulting data set with a Fast Fourier Transform (FFT). This converts the actuator's torque, position or speed signature from the time to the frequency domain. The resulting information is very useful at pinpointing any components in the mechanical drive train that have failed or are about to fail. Only the QX or MX has the FDA feature in its View Diagnostics menus.

The QX also offers Bluetooth technology as an option, up to 10 meters. When used with the Flowserve Limitorque graphical software interface, Dashboard™, diagnostic information can be transferred easily to a PDA with Windows Mobile 5 or greater, laptop computer or smart cell phone. In addition, off-line configuration changes can be uploaded and actuator configurations transferred from one device to any number of subsequent actuators.



Dec clutch Lever

Three conduit openings are standard with the option of a fourth.

Terminal Compartment with O-ring seals that permit a double-sealed compartment, isolating the electronic controls from the environment.